Name:____

Simulating Natural Selection Lab

Background:

It was known long before the time of Charles Darwin (1809-1902) that the fossil record indicated that organisms change over very long periods of time. Although many scientists accepted this concept, known as *evolution*, the factors that cause these changes to occur were not understood. Both Darwin and another naturalist, Alfred Russel Wallace (1823-1913), made some observations on separate trips around the world that helped them to identify one of the factors behind the process of evolution. Darwin and Wallace described the concept of *natural selection*, sometimes described as survival of the fittest. Organisms that are well matched to the habitat where they live will produce more offspring than those that live in less suitable environments.

The traits that an organism has that allow it to fit well within its environment are called *adaptations*. Adaptations occur because of differences in genes (DNA) in different individuals. Each individual produced by sexual reproduction is slightly different than either of its parents. If an individual inherits a characteristic that makes it better at getting food, or escaping predators, or attracting a mate, then it may live longer and reproduce more frequently – in other words, it has been selected by nature to be more successful than other organisms in its population. It is important to realize that although natural selection influences how successful an individual will be, evolution only occurs within large groups of organisms of the same species, called *populations*, over time. Individuals cannot evolve – they already inherited all of the instructions for who they can be in their DNA.

The result of natural selection causing changes in a population over time (evolution) was observed by Darwin on his trip in 1835 to the Galapagos Islands near Ecuador. The Galapagos Islands form a chain not far from the South American coast. Darwin noticed that each island had a different type (species) of small finch. All of these finches, now known as Darwin's Finches, were very similar to each other and to a mainland species in many ways. However, their beak size and shape varied from island to island. Each different beak type was particularly well suited to obtaining a certain type of food. For example, one finch species had a large, heavy beak that was very good at crushing the thick-shelled seeds present on the island where they lived. Another finch species from a different island had a sharp, thin beak that was good at spearing insects for food. Darwin surmised that as the islands were produced by volcanic action, some mainland finches found their way (probably by being blown there in a storm) to the new islands. Of the finches that made it to the island, those that were well suited to gathering the type of food present there were very successful and produced lots of offspring. The birds that were not good at gathering the island food died, and left few, if any, offspring. This process continued as the finches spread from one new island to another, eventually producing the different species of finches recognized today. This is an example of natural selection resulting in a process called *adaptive radiation*. The birds were able to radiate (spread) out to new habitats because of their different beak adaptations. Again, notice that each individual bird did not change its appearance to take advantage of food resources. Each individual either had the right equipment or it didn't. If it did, it left more offspring and, over time, the population of birds was filled with many more well-adapted than poorly-adapted birds.

New adaptations result from changes in DNA structure during reproduction. These changes in DNA are called *mutations*. Most mutations that occur are either detrimental (harmful to the individual), or they are neutral (neither help nor hurt the individual). Every once in a while, a mutation occurs that is actually helpful to the individual, just like that mutations that caused the beak adaptations in Darwin's finches. Usually humans cannot observe evolution occurring because it takes many generations for an adaptation to spread throughout a population. However, in the 1800's, the type of genetic change that can lead to the production of a new species was observed in England.

Nineteenth century England saw a great increase in the amount of coal burning due to factory power usage. When coal is burned, soot is released. Vast amounts of coal were burned in English cities. This resulted in a coating of soot being deposited on buildings and trees in and near the cities. Trees and buildings in rural locations were not affected by the soot. The normal bark coloration of birch trees is white, but in industrialized areas, the bark was blackened with soot. The peppered moth (*Bison betularia*), which lives in these areas, has two different color varieties: a light gray, speckled form that blends well with the bark and lichens of clean birch trees, and a black variety that blends well with the soot-polluted trees. The light colored mothers were the most common form of the peppered moth prior to the Industrial Revolution. However, as the soot from the factories blackened the birch bark, the dark form of the moth became more and more common. The hypothesis that biologists formulated to explain their observations was that natural selection (in the form of bird predation on the light moths) cause a shift in coloration from the light to the dark form of moth during this period. This shift came to be known as *industrial melanism* because the color shift was caused by industrial activity, and the dark form of the moth gets its coloration from the pigment melanin.

There has been some recent controversy within the scientific community concerning the methodology used by Kettlewell to validate industrial melanism. However, air pollution controls in England have reduced the amount of soot reaching the trees, lichen has grown back making the trees lighter in color, and the lighter moths have become the most common again. Continuing field studies have repeatedly shown that conspicuous moths are more readily eaten by birds than are inconspicuous moths.

Procedure:

1) Within your lab group determine who will fulfill each of the following jobs. Note: You must keep this job for the duration of the lab. If your group does not have 4 members, the timer and recorder will be the same person
    - Predator
    - Moth distributor
    - Timer
    - Recorder
2) Assemble a "light bark" tree background tray and prepare both light and dark moths
3) The predator should turn around while the "moth distributor" will place 5 moths of each color (10 total) on the background. They should try to "hide" the moths by matching moth markings to bark markings as they randomly distribute them throughout the habitat
4) When the students are ready, the timer will say "Go!" and the predator will have 5 seconds to remove as many moths as possible from the background. They can only remove one moth at a time and may only remove a moth using their "beak" (thumb and one forefinger). They must place the selected moth on the tabletop before "hunting" again. At the end of 5 seconds, the timer will say "Stop!" and the predator must immediately stop hunting.
5) The recorder will count the number of each color of moth remaining on the background. These are the "survivors." The recorder will then record these numbers in Data Table 1 as the Generation 1 survivors.
6) Assume each of the surviving moths has 2 offspring that look exactly like the parent. The "moth distributor" will redistribute the second generation moths (survivors and offspring) while the predator has their back turned. Note: Be sure to flatten any moths that were bent in the previous round.
    - IE: Multiply the surviving moths by 3 (1 for the survivor and 2 for its offspring).
    - Example: If 4 light colored moths survived, then 12 light colored moths would be distributed for the next trial

7) Repeat steps 4-6 for the second generation of moths and record the numbers for the second generation survivors in Data Table 1. Each survivor from the second generation also has 2 offspring.
8) Repeat for a third generation of moths
9) Next, assemble a "dark bark" tree background tray and prepare both light and dark moths
10) Repeat steps 3-8 for 3 generations of moths as well and record data in Table 2
11) Determine the percentage of light vs dark moths for each generation for each background
    - Divide the number of that type of moth by the total number of moths in that generation
    - Round to the nearest whole number
    - Record the percentages in Tables 3 and 4
12) Create 2 line graphs showing the percentage of each type of moth over time using the data from Tables 3 and 4. One graph should show the percentage of surviving moths in the light forest and the other graph should reflect those in the dark forest.
    - Use a dashed line to represent light moths
    - Use a solid line to represent dark moths
13) Use the information found in the background as well as your data and graphs to answer the questions in the analysis and conclusion

Data:

Table 1: Number of Moth Survivors in Each Generation in Light Forest

Generation	Number of Light Moths	Number of Dark Moths	Total Number of Moths
Original Population	5	5	10
1			
2			
3			

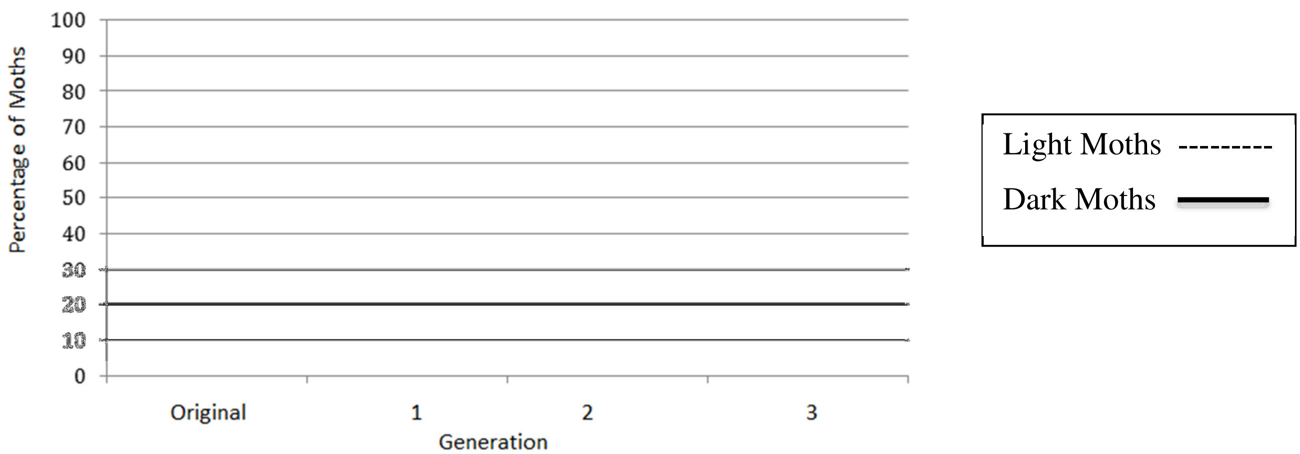
Table 2: Number of Moth Survivors in Each Generation in Dark Forest

Generation	Number of Light Moths	Number of Dark Moths	Total Number of Moths
Original Population	5	5	10
1			
2			
3			

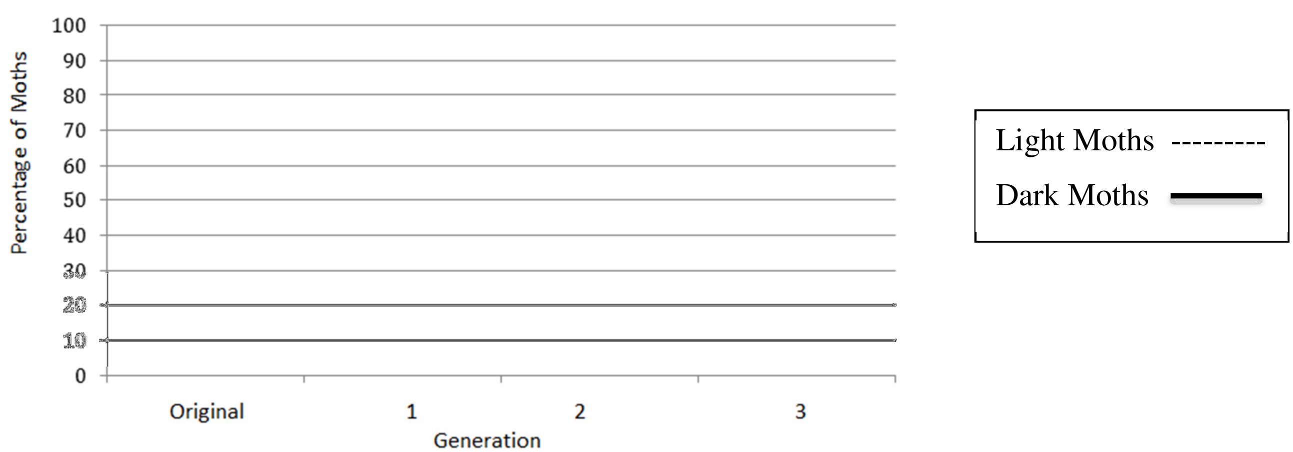
Table 3: Percentage of Light vs Dark Moths over 3 Generations in Light Forest		
Generation	Percentage of Light Moths (# light moths / # total moths)	Percentage of Dark Moths (# dark moths / # total moths)
Original Population	5/10 = 50%	5/10 = 50%
1		
2		
3		

Table 4: Percentage of Light vs Dark Moths over 3 Generations in Dark Forest		
Generation	Percentage of Light Moths (# light moths / # total moths)	Percentage of Dark Moths (# dark moths / # total moths)
Original Population	5/10 = 50%	5/10 = 50%
1		
2		
3		

Moth Populations in Light Forest Over Time



Moth Populations in Dark Forest Over Time



Analysis:

1. Define the following using the information found in the background:
   - Evolution
   - Natural selection
   - Adaptation
   - Population
   - Adaptive radiation
   - Mutation
   - Industrial melanism

2. Who is able to evolve, individuals or populations? Explain your answer

3. Explain why the beak size and shape of the finches on the Galapagos Islands varied from island to island. Include examples in your explanation

4. What caused the initial existence of two different color varieties in the peppered moth populations in England?

5. How does the color of the moths increase or decrease their chance of survival?

Conclusion: Use complete sentences to answer the following

1. What happened to the percentage of each type of moth over time in the light forest?

- Light moths?

- Dark moths?

2. What happened to the percentage of each type of moth over time in the dark forest?

- Light moths?

- Dark moths?

3. WHY do you think this happened? BE SPECIFIC! Relate your answer to natural selection

4. What do you predict would happen to the percentage of each type of moth if the pollution in England was reduced and less soot reached the forest? Explain your answer

5. If there were no predators of the moths in the forest, would the colors of the moth populations change over time? Defend your answer